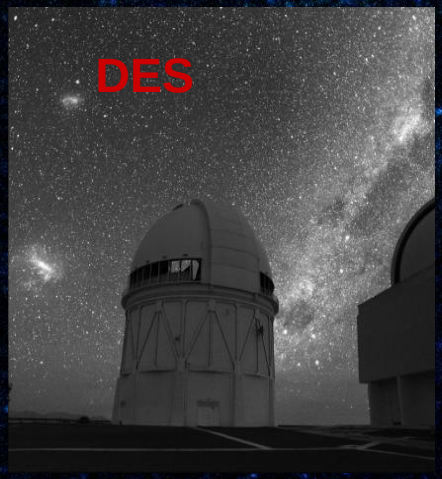
The HEP Experimental Astrophysics & Cosmology Program

Argonne NATIONAL LABORATORY

Dark Matter,
Dark Energy and
Inflation Era Physics



Providing Enabling
Technology for
Future Experiments

The HEP Experimental Astrophysics & Cosmology Program

CMB (SPTPol)

J. Carlstrom (HEP) ** (GL)

C. Chang (HEP) **

V. Novosad (MSD)

G. Wang (HEP)

V. Yefremenko (HEP/MSD)

Sudeep Das (Offered Schramm Fellow w/ Cosmic Theory group)^(Jun 2012)

New Postdoc (HEP)

Dark Energy (DES)

Kyle Barbary^(Offered Directors Fellow w/DES group Mar 2012)

R. Biswas^(HEP)

E. Kovacs (HEP)

K. Kuehn^(HEP)

S. Kuhlmann (HEP) (GL)

H. Spinka (HEP)

Indirect Dark Matter (VERITAS)

K. Byrum (HEP) (GL)

G. Decerprit^(ANL/DESY)

R. Wagner (HEP)

B. Zitzer^(HEP)

GL – Group Leader

** Joint w/ Univ. of Chicago

^ Postdoctoral Fellow

HEP – High Energy Physics Div.

MSD – Materials Science Div.

ALCF – Leadership Computing Facility

The HEP Astrophysics & Cosmology Program Evolution

Experimental astrophysics & cosmology

VERITAS → CTA
(Indirect Dark Matter)

DES → LSST
(Dark Energy)

CMB/SPT → SPTPol → SPTPol Upgrade
(Enabling Tech to study Inflation)

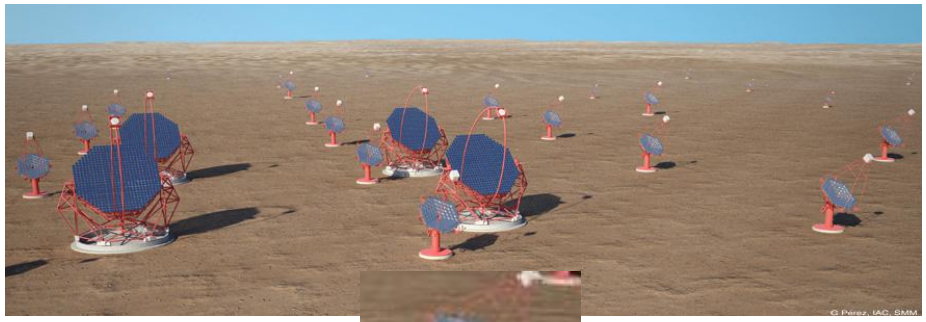
New Cosmic Frontier Theory Group

LDRD Supported Effort on Supercomputer precision Cosmology

→ LSST Simulations
→ Theory/Precision Cosmology
→ Theory/Supercomputer Simulations

VERITAS and CTA

US invented this field (with DOE & NSF support)



ANL-DESY-Saclay design

VERITAS

Currently the most sensitive TeV Observatory in the world.

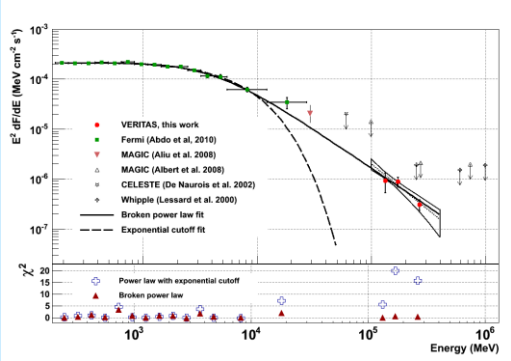
- L2 trigger upgrade for VERITAS: Now Mostly Commissioning
- Science – Continued Data analysis focusing on DM, LIV and fundamental physics

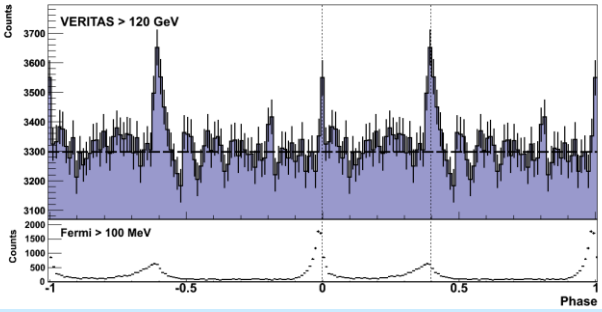
CTA

- DM, LIV and fundamental Science
- Provide enabling technology for next generation
  - Topological Array Trigger
  - Large Area Photodetectors for camera
- Utilize unique lab resources to design new economical & automated mechanical telescope structures

VERITAS Science

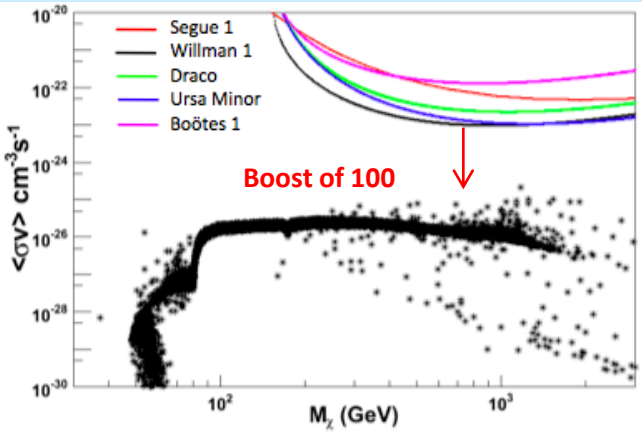
First Detection of Crab Pulsar above 100 Gev, Science 334, (2011), 69.





LIV studies using Crab Pulsar - Zitzer

- Estimate LIV limits w/CRAB comparable to AGN (HESS & MAGIC)



First VERITAS DM Paper.

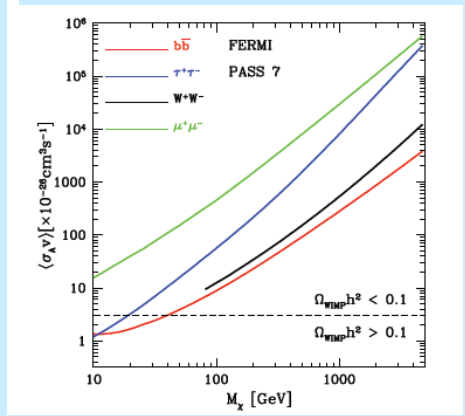
Indirect DM search using VERITAS dwarf spheroial data ApJ 720 (2010) 1174

R.Wagner & A.Smith led analysis and paper writing

VERITAS Deep Observations of Segue 1; Phys Rev D, 85, 062001 (2012)
M. Vivier (Delaware)

- Excludes some DM models
- Complementary to other measurements

Exclusion of WIMPs w/M < 40 GeV using FERMI Dwarf data



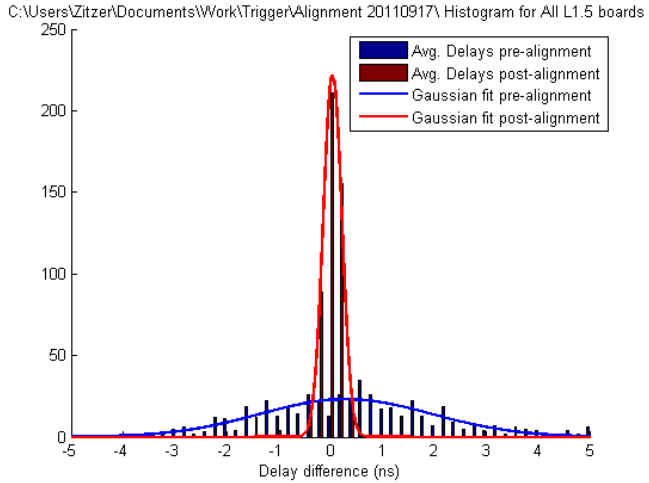
Geringer-Sameth and Koushiappas, PhysRevLett 107.341302 (Brown)

ANL and Brown Univ.

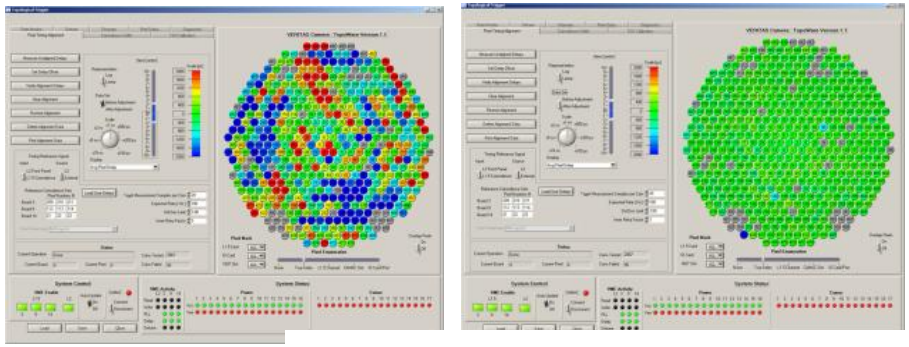
Use frequentist-statistics method on the VERITAS dwarfs to extend the Fermi limits into the high mass region available to VERITAS.

Brown – method for stacking
Argonne – data analysis (PSF, acceptances, etc..) & systematics (Decerprit & Zitzer)

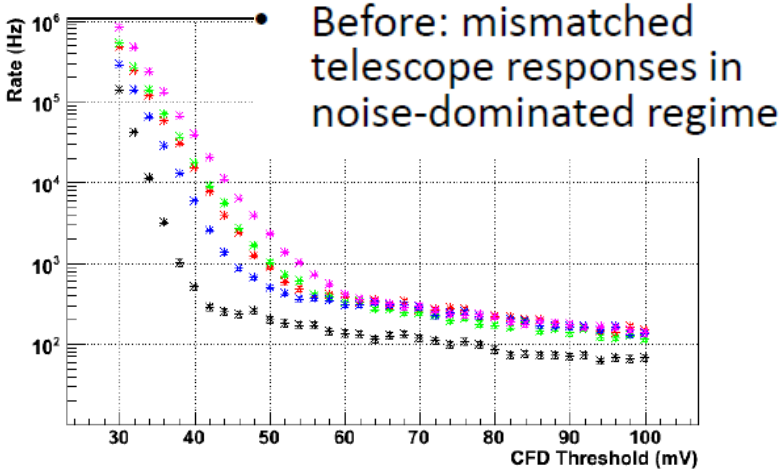
VERITAS Upgrade
New 400MHz FPGA L2 Trigger



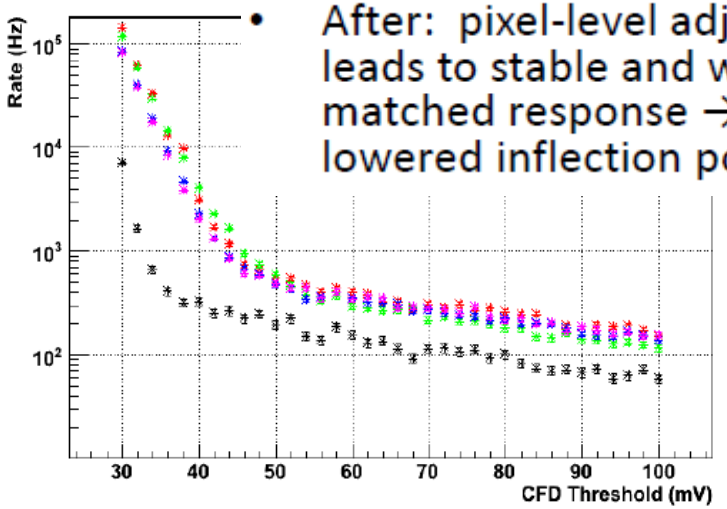
Installed Nov 7-14, 2011! Came up working. Commissioning still underway, Anderson, Drake, Zitzer, Byrum with Krennrich, Weinstein (Iowa State Univ.)



Pixel to pixel alignment better than 500psec

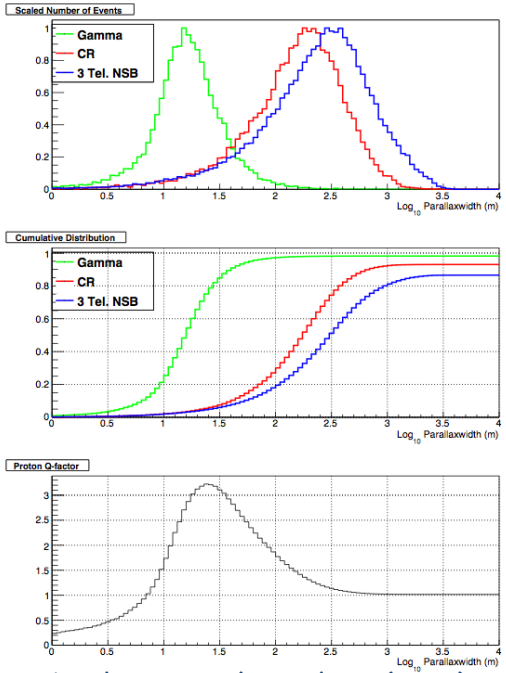


Before: mismatched telescope responses in noise-dominated regime

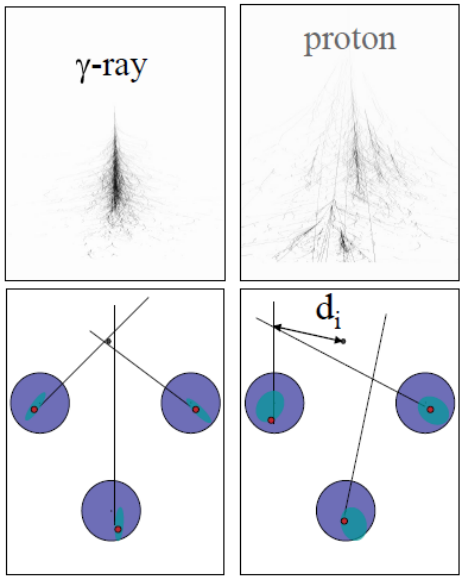


After: pixel-level adjustment leads to stable and well-matched response → to lowered inflection point

CTA R&D – FPGA based Topological Array Trigger



Credit: M. Schroedter (ISU)



Drake,Anderson, Byrum with Krennrich & Weinstein (ISU)

Array Trigger Concept: Use Parallax at trigger level where simulations indicated an order of magnitude cosmic-ray reduction, while keeping 90% of gamma-rays.

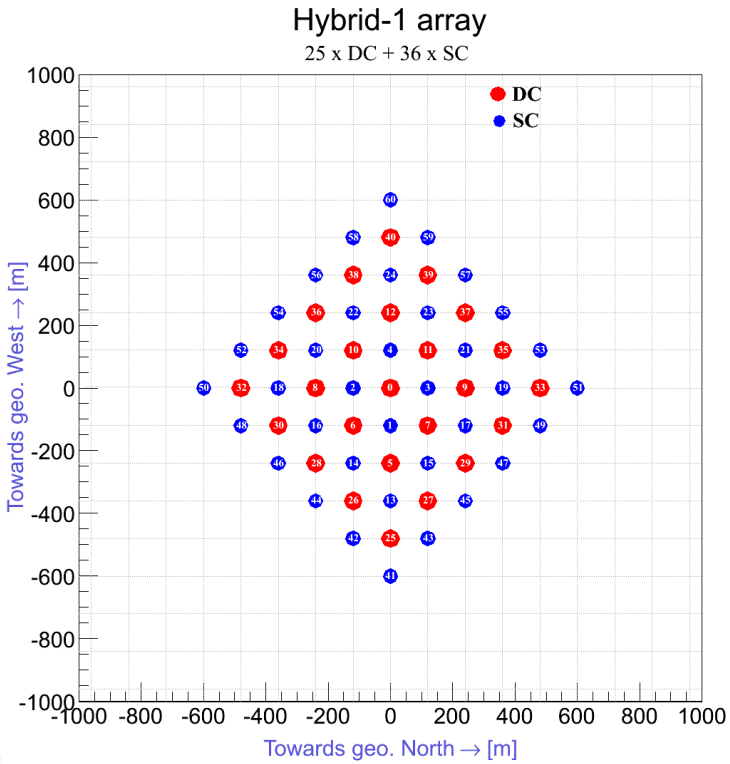
Early array design & L2 prototype by ANL & ISU led to (VERITAS L2 upgrade).

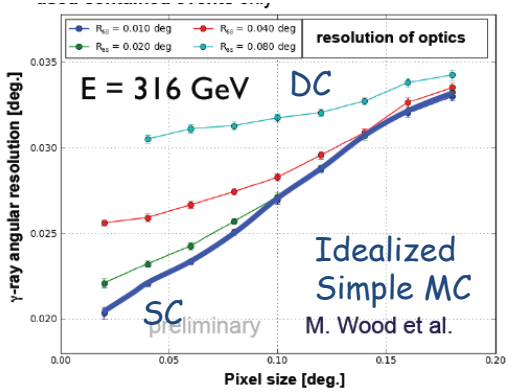
For CTA: attractive option to deal with deadtime and data rates.

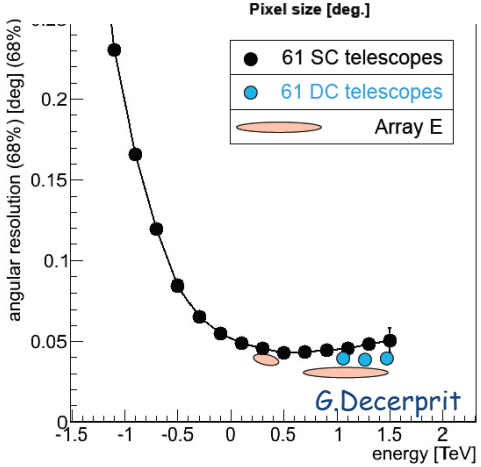
Trigger concept and technology implementation for CTA begun (Advanced Telecommunications Computing Architecture (ATCA))

CTA – Simulations – G. Decerprit in collaboration w/ DESY, Columbia & SLAC

- Simulation of a mixed array: Schwarzschild-Couder (SC) & Davies-Cotton (DC) telescopes.
- Target energy range: 50 GeV - 30 TeV
- **GOAL:**
  - **assess the general performances of a mixed array**
  - **compare SC telescopes with DC telescopes**



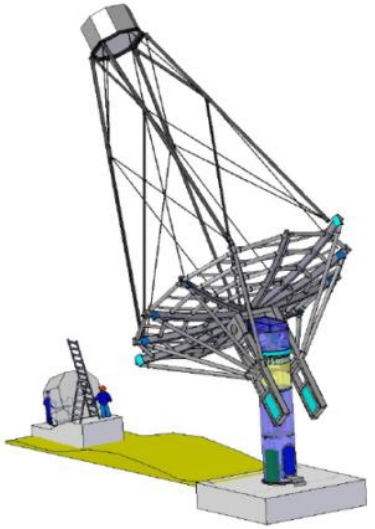




- Note that the pure-DC array analysis is much more optimized than the pure SC array
- Room for maneuver for agressive optimization
- These preliminary results are promising

ANL lead DC Mechanical OSS Telescope design for CTA R&D

Victor Guarino, DESY, Saclay



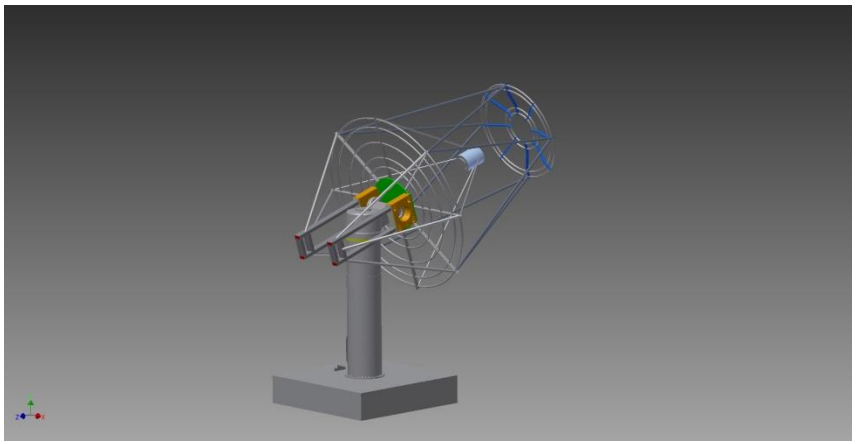
Quarter dish for DC telescope. All components built in Chicago based US industry (with special capabilities – rolled beams)

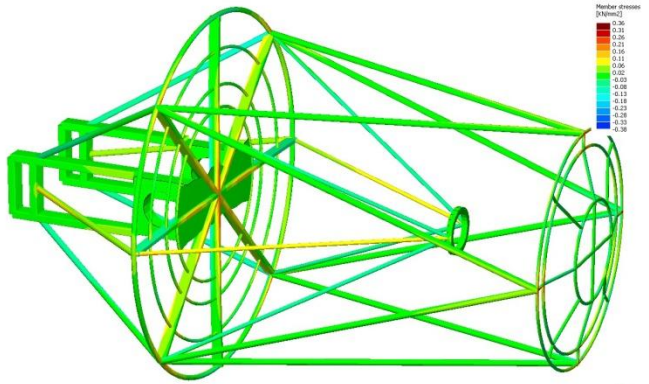
Quarter dish in Berlin with mirrors installed and mirror controls for alignment. This has been a big success for finalizing telescope design.

CTA R&D Mid Sized Schwarzschild-Coude (SC) Telescope Mechanical Designs

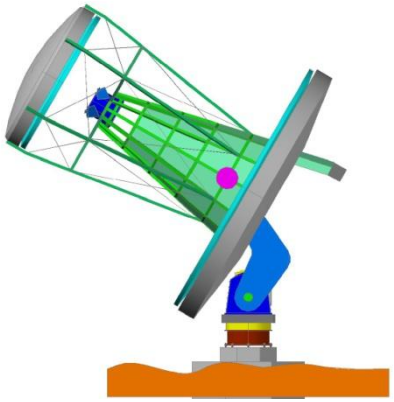
Victor Guarino,
UCLA, DESY, Krakow

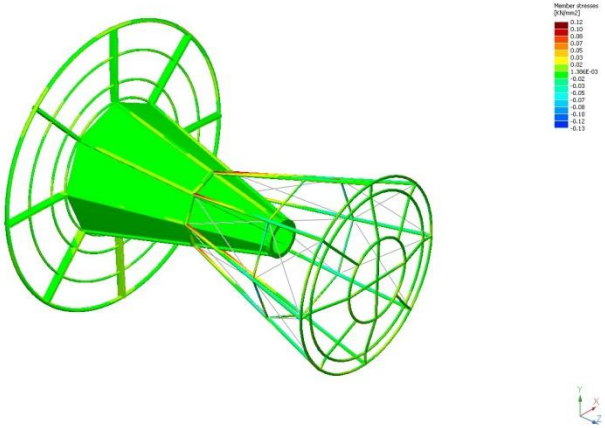
We have begun the FEA structural analysis needed to evaluate the deformations of OSS of each design concept. Collaborating w/UCLA





Our earlier SC design mounted on DESY positioner





Krakow SC design

Summary

Analysis of VERITAS data

- Indirect Dark Matter using Dwarf Spheroial Galaxies
- Lorenz Invariance Violation using AGNs

Commissioning and optimizing of L2 trigger

CTA (Present and Future)

- MC Simulations for optimization of telescope designs (traditional DC vrs new dual mirror) (ANL/DESY pd)
- Mechanical engineering of new and traditional telescope designs
  - ANL/DESY/Sacclay Davies Cotton 12m telescope is the CTA mid-sized telescope baseline.
  - Leading mech. Design of new novel dual mirror telescope (CTA-US proposal (w/UCLA, Krakow,DESY)
- Real time Array Level Topological trigger using event topology (w/ISU)
  - Leverages VERITAS L2 trigger
- Large Area Photodetector R&D program